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The American Biology Teacher

Vol. 5 DECEMBER, 1942 No. 3

Demonstration of Hereditary and Environmental Effects in Corn Seedlings

EDWARD C. COLIN
Chicago Teachers College, Chicago, Illinois

Corn seedlings segregating for green and albino in the ratio of three to one are raised in many biology laboratories for the purpose of demonstrating Mendel's first law of heredity. Two additional biological principles of general application among plants and animals are easily demonstrated with this same material. In the first place it may be shown that heredity and environment are both indispensable in the development of the organism and therefore that neither one of these factors can be considered more important than the other. Secondly, the demonstration can be used to illustrate the fact that a hereditary effect may resemble closely an environmental effect. The history of a given case must be known if the observer is to ascribe correctly the role of each of these factors.

In maize, albinism is due to a recessive mutation which prevents the formation of chlorophyll. After the albino seedlings have exhausted the food stored in the seed they wither and die of starvation because of their inability to synthesize carbohydrates. Segregating ears are produced by self-pollination of heterozygous normal green plants. Seeds from such ears are obtainable from the laboratory supply houses. Those used in the demonstration here illustrated were purchased from The Ohio Biological Supply Co., Columbus, Ohio. The environmental factor chosen for study is light.

In a tray filled with good black earth the seeds are planted in rows. As soon as the seedlings begin to break the surface a light-tight cover (Fig. 1) is placed over the rows occupying one-half of the tray. The cover illustrated is an open box made of heavy galvanized iron. The tray is constructed of the same material.

FIG. 1. Albino corn seedlings growing among normal green plants. A similar population is growing under the box in the absence of light.

All environmental factors save the one which is to be varied should of course be held constant. Although the present set-up does not fully meet this ideal, it is probable, considering the known facts about plant growth, that the chief effective factor in the observed differences is the presence or absence of light. In order to permit circulation of air into and out of the cover the central region of the top is perforated; and in order to prevent light reaching the plants through the holes a second steel top is fastened inside the box about one inch below the outer top. This inner top is about one inch smaller in both dimensions than the box, thus allowing circulation of air without the admission of light to the plants. As a further precaution all inside surfaces are painted black for the absorption of light rays entering through the holes in the top. The cover was made to order in a tin shop at a cost of $2.50. A corrugated paper carton without perforations gave results similar to those obtained with the metal cover. The permanent cover has been found convenient, however, since the demonstration has become a standard procedure followed one semester after another. Among the advantages of the metal cover are these: the sharp edges cut into the soil and exclude the light from below while the metal itself is affected very little by the water applied to the plants; the box may be made in any size desired, and when once constructed it is always available.

If the soil is thoroughly soaked before the cover is placed in position no water need be added to the plants under the cover. After planting, approximately two weeks are required for the seedlings to reach the height shown in the photographs, the exact time depending on the temperature.

The apparatus as described probably furnishes a reasonably good control of all factors in the environment except humidity. Under the box the humidity is naturally much higher than it is outside. Likewise, the concentration of oxygen and of carbon dioxide is probably somewhat different for the two groups of plants: this point has not been tested. At times there may be some difference in temperature, especially if the cover is exposed to the direct rays of the sun. With a metal cover it is best to keep the tray out of the sun.

Subject to the foregoing qualifications, the striking differences between the plants growing in the opposite halves of the tray (Fig. 2) may be attributed to the light factor. It is obvious that

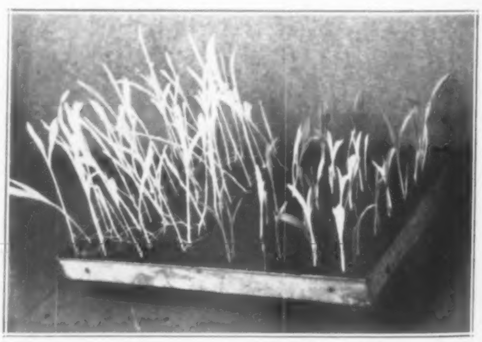

FIG. 2. Corn seedlings, all of the same age. The tall plants at the left were grown in the dark.

among the plants raised in the light the primary difference between the albino plants and the green ones is due to heredity. In the dark, normal plants are unable to manufacture chlorophyll; and at a distance of a few feet they look like albinos, although on closer inspection they may be distinguished from the mutants by their pale yellowish color. In a black and white photograph this difference is not apparent. Absence of light clearly produces an effect on the color of normal plants very similar to that produced by the albino gene.

Incidentally, another interesting environmental effect may be noted: the corn grown in the dark is much taller than the corn raised in the light. Absence of light stimulates elongation of the stem, and as a result some of the roots are pushed above ground.

Summary

In the demonstration herein described it is evident that under the normal environment heredity is much more important than environment in producing the observed differences in color among the corn seedlings. On the other hand, with plants raised in the dark, hereditary differences are of slight importance as compared to the great modifications produced by the environment. Strictly speaking, characteristics are not inherited: genes are inherited, and the genes merely determine potentialities of development in particular directions. The realization of the potentialities in a developing organism depends upon the environment. A modification of the environment may produce profound changes in the end result.

The Influence of Biology on Theories of Human Behavior[1]

FRANK J. BRUNO
Department of Social Work, Washington University, Saint Louis, Missouri

There is a strong human tendency to over-simplify social phenomena: to find a panacea for the ills that beset us. Probably those whose special knowledge lies in the biological sciences are not greater sinners in this respect that other men. But there is a peculiarly subtle form of danger facing the biologist not shared by specialists in other disciplines; biological organisms are alive; they have self-determination; they are under certain controls in their development which we call heredity and environment. Man is a biological organism and the analogy of his behavior with that of pre-human species is treacherously easy to make. Nor are such analogies always misleading. Perhaps the most brilliant biological hypothesis ever made—the doctrine of evolution—has been found useful in explaining social as well as biological phenomena. But to a larger extent than any of us are likely to realize we find it easy to transfer, uncritically, as did the experimenters on the alcoholization of guinea pigs, the findings in prehuman phenomena to human situations; or to assume that if we know what biological change takes place we can predict behavior.

[1] Presented before the National Association of Biology Teachers, Dallas, Texas, December 29, 1941.

Jennings in his "Prometheus" has a significant statement on that point: "When the biologist from his knowledge of other organisms is tempted to dogmatize concerning the possibilities of human development, let him first ask himself, how correctly could I predict the behavior and social organization of ants from a knowledge of the natural history of the oyster? Man differs from other organisms in these respects certainly as much as the ant does from the oyster; for these distinctive aspects of his biology only the study of man himself is relevant. There is nothing in the general principles of biology which says that increase and diffusion of knowledge shall or shall not do away with warfare, solve the problem of over-population and otherwise bring to realization the dreams of reformers."

Within recent history several distinct biological theories have widely influenced scientific as well as popular understanding of human behavior. I wish to speak of four of them: heredity, focal infections, endocrines and vitamins.

Beginning with Dugdale's classical study of the Jukes in 1877[2] reinforced by the discovery in 1900 of Mendel's lost monograph and then tied in with intelligence by Binet's method of measuring supposedly innate intellectual capacity of children, the early Twentieth Century was characterized by a strong burst of interest in theories of heredity and their application. While lip service was given to environment, practically heredity alone seemed to count, as one can see by consulting Conklin's "Heredity and Environment." These concepts tended to create a biological determinism that raised serious question as to the validity of reform, including even progress in public health measures. Such a book as Ludovici's "Lysistrata," published in 1925 denied that humanity had actually made any progress, a point of view brilliantly defended by H. L. Menken in far more popular terms. It is questionable whether such a deterministic theory was ever accepted literally by many persons, at least in their practical plans for living. Its major results were to lead to more careful criticism of plans for reform, as well as to a more careful scrutiny of the accuracy of the theory itself. Perhaps it is significant that not until the early twenties did a biologist (Jennings) realistically question the controlling influence of heredity or see the interdependence of heredity and environment. In the Spring of 1922, Walter Lippman, in a series of articles in the New Republic, of which he was then editor, tore to shreds the theory of the predominant place of heredity in fashioning human behavior, using the very data of geneticists for his analysis.

In the area of public welfare the rigid theory of heredity may have exerted some depressing influence. For instance, since the turn of the century and especially since 1910, much less interest was shown in the treatment of the mentally deficient than characterized the two or three preceding decades. The pioneers in this field—Fernald, Johnstone, Rogers and others—who started their work in the last decades of the Nineteenth Century, were greatly interested in mental deficients sent to their institutions, and showed resourcefulness in bringing out their latent powers; but their successors have shown no such capacity, being apparently willing to accept biological determinism as a reason for inactivity. This may not be the correct reason for the change; but the change itself is obvious, as is the fact that the pioneers were trained before the deterministic theory came into acceptance, and their successors after.

[2] Dugdale, *The Jukes*, Saratoga Meeting of the National Conference Charities and Corrections, 1877, pp. 77 ff.

In the field of penology our rugged individualism has had a curious influence in blocking any effort to treat the criminal instead of punishing the crime. Even the mild suggestions made by former Governor Alfred E. Smith to the Constitutional Convention of New York in 1928 received no serious consideration, although based upon the findings of physicians, anthropologists, and psychologists in this country and abroad.

In the field of dependency, the concept of biological determination reinforced the existent popular belief in the inferiority of persons on relief,—a belief as old as class divisions in society, and very firmly held, probably as a "mass defense mechanism" for the pocketbook!

In the depression winter of 1913–14, the Municipal Lodging House of New York City gave an intelligence test to every tenth man applying within a stated week. I witnessed the tests. The men, for the most part, looked upon them as a huge joke, giving "smart" answers to the questions. Since these were not the orthodox replies, they were marked down, and the record stands today in New York City that this group was composed of inferior persons. In my humble judgment, the men were brighter, in general, than the examiners, at all events they made good comedy of what was undertaken as sober scientific research.

Perhaps the best expression of thoughtful opinion among professional workers with dependent deficient and delinquent persons would be these quotations: one from Jennings,[3] "So long as living conditions are bad, we do not know what ills are due to poor genes. We must therefore correct the bad living conditions . . . measures of public health must be carried out; overwork and bad living conditions done away with, faults of diet . . . corrected; economic ills conquered; grinding poverty abolished. When these things are done, then it will be possible to discover what ills are due primarily to defective genes." And two, from Scheinfeld[4, 5] "we are not yet able to point to any particular type of body, face, head or skeletal structure in normal individuals as definitely correlated with any type of behavior" and "Studies of the possible role of heredity in human wrongdoing bog down because of our inability to disentangle any inherent crime tendencies from the environmental factors in which they are enmeshed. So where the heredity factors are so vague and the environmental ones so clear, it would seem if we want to do anything about crime, we should worry less about what is inside people and more about what is outside them."

The relation between infections, especially chronic ones, and behavior is more subtle, and probably most of our generalizations about it are superficial. One recent popular writer says "Diseases also affect temperament, and in very diverse ways. Tuberculosis has been called the cheerful disease. The sufferer from it is generally optimistic. In contrast, the sufferer from diabetes is more likely to be filled with gloom if not with despair. Indigestion nurtures a cantankerous spirit. It is probably impossible for a person with a toothache to be an optimist."[6]

Several studies have been made in our Department at Washington University on the relation of specific diseases to subsequent behavior, but there is yet to be found by means of the best devices of correlation available any specific behavior which can be ascribed to a disease. This does not mean that illness is of no significance in behavior. It has great

[3] Jennings, *Biological Basis of Human Behavior*, p. 250.

[4] Scheinfeld, *You and Heredity*, p. 294.

[5] *Ibid.*

[6] Needham, *About Ourselves*, p. 169.

meaning; for in spite of our moralists, frustrations are dangerous experiences. We all have our degree of tolerance for such experiences; when that point is passed, we break, and take to more primitive forms of behavior. This, of course is social psychology, not biology, but its significance for this discussion is that it is the frustration of illness, not its specific biological character, that turns a patient who up to that time has been a well-poised individual into a complaining neurasthenic for the rest of his life. It is precisely the same frustration with respect to efforts to acquire self support which turns an independent, self-respecting workman into a shameless pauper. In practice, with marginal persons who become charges upon the State, all efforts should be made to restore health, remove sources of infections—yes, even tonsils and adenoids—so as to lay the basis for recovery of sound morale, a recovery more easily achieved if some of the unnecessary sources of frustration are removed.

The subject of the endocrines is far more difficult, and perhaps a layman should not undertake to discuss it. However, I shall only try to reflect what my profession thinks of it as influencing behavior. Perhaps a quotation from Haskins[7] will give some idea of the vast unknown we face in this area: "We are what we are in no small measure by virtue of our thyroid glands. Our development before birth and through infancy depends upon their functional integrity. The hurdles of puberty are taken with their aid, a pinch too little of thyrozine spells idiocy, a pinch too much spells raving delirium. By its very mobility the thyroid plays a major role in keeping us attuned to our environment. Nature has done much with the thyroid hormone. Can man with growing intelligence do more?"

We are not quite sure it will do all of these things for human beings; but we have seen in some pathological conditions very effective results from endocrine therapy. At times it is the diabetic who is given a new lease on life; at others, excesses or deficiencies of thyroid hormones, with their distinct emotional phenomena, are corrected with what seems miraculous results. We have seen the endocrines, like the vitamins, used as means of building up bodily resistance to infections, and what we have seen makes us eager for the next advance in that fascinating area of physiology.

Endocrinology is significant to us as a means of health, as a preventive of disease, and sometimes as the therapy to treat disease. Pathological endocrine conditions are so terrible that the concept of frustration seems weak to describe the resultant behavior; their victims have, usually, long passed their limits of tolerance and require heroic means of cure. For instance, the endocrine deficiency in the schizophrenic results sometimes in psychoses, with all the phenomena of that type of insanity; a frustration so serious that the patient is quite incapable of facing reality. And as sufferers from this form of abnormality exceed in number any other single type of insanity, endocrine theory of its origin and endocrine therapy belong to the increasing resources of medicine on which we rely but can have no competent judgment.

Perhaps by this time enough has been said to make unnecessary much discussion of the effect of the knowledge of the vitamins upon our understanding of human behavior.

Dietetic information has given relief officials standards which enable them to

[7] Haskins, *The Tide of Life*, p. 100.

determine food, in quantity and kind necessary to maintain life in an efficient manner. Progressive and adequately financed relief administrations aim to provide enough food of the right kind to their clients, and they early become aware of the difference between carbohydrates and proteins, as they are now learning about vitamins and the place they play in diet and health. In backward and poorly financed jurisdictions the story is less satisfactory. It is possible to satisfy hunger and even to keep up weight by substituting carbohydrates for food containing proteins and vitamins. But as the Child Experiment Station at the State University at Iowa demonstrated, such an adjustment left children—and probably adults also—undernourished and liable to contract contagious diseases, even though the diet deficiency could not be detected in weight or unsatisfied appetite.

The recital I have just given is a short and all too sketchy picture of how those who have to deal with people as people on a professional level have appropriated some of the findings of the biological sciences. An adequate statement would go far beyond the scope of a twenty-minute paper. But short or long, the story is a fascinating one, and if I may be so bold as to epitomize is, I should say that those whose job it is to understand human behavior may look with critical eyes upon what the biologist claims to be the social significance of his discoveries but eagerly seize upon every new advance in that field for what it can tell of the conditions under which life has to be lived.

MEETINGS

The Detroit and Chicago Regional Meetings were both well attended and had excellent programs. Committees appointed by the local clubs made all the arrangements, and I wish to congratulate them on the splendid results achieved by the various committees. The financing of these meetings is not difficult and the benefits are considerable, both to the local organization and The National Association. It brings more local people to the meeting than usual. They become interested and join both the local and the national. The programs give up-to-date information. At the banquet of the Chicago meeting, Dr. Fitzpatrick's address on *The Biology of Flight* was an example of a timely topic that was full of interest and scientific information that we can used in our class rooms.

If any other group would like to sponsor a Regional meeting, I would be glad to correspond with your President or Secretary.

M. A. Russell

THE NEW YORK MEETING

Just when the December issue of The American Biology Teacher was ready for the printer, word came of the cancellation of the 1942 convention of the *American Association for the Advancement of Science*. At first it was hoped that a Regional Meeting of the New York area might be held, but a hurried investigation showed this too to be impractical under the existing conditions.

This cancellation, coming at the time it did, made necessary considerable revision of the current issue, even after the corrected page proof had been sent in. We hope the readers will bear with us in the resulting delay in printing and mailing.

The Editors and Officers.

President's Page

What are we doing to meet the war time situation? I believe biology is a basic science and should not be crowded out of high school schedules by pre-induction courses. In fact, I believe biology should take its place with physical sciences in the pre-induction curriculum. The lessons we may teach can be vital to the boys who will become soldiers and the girls who may become war workers.

The following is a copy of the War Biology course of the Highland Park Senior High School as outlined by a committee of the biology teachers, C. E. Altenburg, Wilhelmina Andrews and M. A. Russell. This has been made a required course for the tenth grade in Highland Park, Michigan.

BIOLOGY I.

GROUP I. *Conservation of Natural Resources*

a. Forestry. Lumber for ships and other war necessities.
b. Agriculture. Relationship of the farmer to the war effort.
c. Gardening and its importance in winning the war.

GROUP II. *Relationship of Animals to Human Welfare*

a. Insects. As bees for honey and pollination. As disease carriers and their control.
b. Protozoa as disease carriers and their control. As a basic food supply.
c. Worms and their relationship to diseases in man.
d. Reptiles as food and as a source of serums.
e. Fish, amphibia and mammals as a source of food and other products important to man. Dogs as messengers, etc.
f. Birds and their relationship to man. Doves as messengers. Birds as models for airplanes.
g. Plant and animal reproduction. Sex education.

GROUP III. *First Aid*

The Standard Red Cross Course by a certified instructor.

BIOLOGY II.

GROUP I. *The Microscope*

a. The microscope and its importance in the field of medicine. Parts of the microscope and its use.

GROUP II. *Heredity in Man*

a. Mendel's laws as applied to man. Races of men and the truth about super-races.
b. Heredity and the improvement of plants and animals.
c. Heredity and good health.

GROUP III. *Photosynthesis*

a. How man's food supply is manufactured by plants. How a knowledge of photosynthesis helps man to know the importance of an adequate transportation system.
b. The study of plastics—artificial rubber, etc.
c. Nutrition—Foods—Food tests—Vitamins—Daily health chart—Master diet.
d. Food preservation.

GROUP IV. *Physiology—Anatomy—Hygiene (of Man)*

a. The Nervous system
b. The Skeletal system
c. The Muscular system
d. The Digestive system
e. The Circulatory system
f. The Respiratory and Excretory systems
g. Biology of Flight
h. Diseases—Remedies—Allergies—Cancer—Tuberculosis, etc.
i. Bacteria and Yeasts—Fermentation and Alcohol
j. The Study of alcohol, tobacco, dope and other narcotics and their relation to man
k. Sanitation

GROUP V. *Safety*

REPORTS

Bubonic Plague and Dope in China. What the Japanese are doing in China to exterminate the Chinese.

Typhus—The disease in Russia and Poland. What can be done to combat it.

Viruses—How viruses are cultivated and their importance in this war.

Cancer-Causing Chemicals.

Nutrition in War—Dehydrated and enriched foods.
The United States Army Diet—Its study by boys who are prospective soldiers.
Basic Diets Recommended by the Government—Daily pattern of nutrition.
Trace Elements—Their importance in the future of nutrition.
The Sulfonamides—Their relation to the treatment of infections.
Shockless Surgery—With tourniquet and ice.
Recent Advances in Biology—Hydroponics—chemicals and plant growth.
(auxins) colchicine and sulfanilamide (alterers of heredity).
Gerontology (new science of aging).
Are enzymes, bacteriophages, and viruses alive?
A living crystal. The virus of tobacco mosaic disease.
New theory of chromosomes and genes.
Hormones—New insulin for diabetes.
Chemical organizers (activators) in embryos.
Refrigeration for cancer and relief of pain.
Human hibernation.
Human cells made immortal by supercooling.

CLARENCE E. ALTENBURG
WILHELMINA ANDREWS
MERL A. RUSSELL

THE FIFTH ANNUAL CONVENTION

This page was to have been occupied by the program of the fifth annual convention of *The National Association of Biology Teachers*. With the existing uncertainties of travel and the like, program making was difficult this year. It took a large amount of hard work on the part of many officers and others. All manifested splendid cooperation, and the result was a program, complete in every detail, that was far above average in every respect. It went to the printer without any "Speaker to be announced," or other vacancies. This in itself is a tribute to the care and foresightedness of those involved in the task. Recognition should go particularly to Mr. Russell, Miss Trowbridge and Dr. Mann.

At this writing no information has been received as to the manner in which nominations for 1943 officers will be made. It is expected that a meeting of officers and certain committee chairmen will be held in the near future, and that the election and other important matters of business of both the association and the journal will be carried out with as little delay as possible.

The readers of THE AMERICAN BIOLOGY TEACHER can help to a considerable extent in making up for the loss of the convention. The editors in the past have received many valuable suggestions from conversations with members in attendance at the meetings. They are deprived of this effective source of information and inspiration this year, but you, the readers, can make it up, at least to a considerable degree.

If you have anything in mind that you think would be of benefit to the journal, let the editor or one of the associates know about it. If you know of some one who has a good idea for an article, suggest to him that he write it up and submit it. If you have some little trick that makes your own teaching of biology more vital or easier for pupils to grasp, send it in. It may be only a sentence; the items in the feature *By The Way*, which appears on the following page, are nearly all suggestions that have come from teachers. This feature can be continued indefinitely if you will send in suggestions for it.

The journal should reflect the opinions and attitudes of all of its readers; actually of course it reflects only the opinions and attitudes of those who take the trouble to make themselves known to the editorial staff. This year, without the annual meeting, it is especially necessary that a large number of readers make their opinions and attitudes known.

JOHN BREUKELMAN

DETROIT REGIONAL MEETING

The Detroit Regional Meeting of the *National Association of Biology Teachers* was a decided success and exceptionally well attended. It was held on October 10, 1942, at the Book-Cadillac Hotel, with a well-rounded program for both morning and afternoon sessions, terminated by a banquet in the evening. The speakers gave up-to-the-minute messages and the entire program was well balanced.

The keynote of the morning session was *Biology and Defense*. The meeting was opened by the chairman, Miss Betty Lockwood, introducing President Merl Russell, who gave an illustrated talk on "Victory Gardens in the Detroit Area." His slides showed the actual work being done by the children in the gardens of Highland Park which he supervised last summer.

M. C. Lichtenwalter of Lane Technical School, Chicago, gave a helpful and timely talk, also illustrated, on "Practical Problems for a Vocational Biology Course." The address by Dr. Arthur Smith of the College of Medicine of Wayne University, Detroit, on "Nutrition—a Factor in the National Effort" aroused much interested discussion and favorable comment. The next speaker was Dr. Loren Shaffer of the Detroit Department of Health who spoke on "Venereal Disease as a Public Health Problem." Further helpful suggestions for home and school gardens were given by the last speaker of the morning, Dr. Paul Krone of Michigan State College, in his lecture "Gardening for Defense."

The theme of the afternoon session was *Biology in Conservation*. This interesting series opened with brief talks on Conservation in the schools by pupils representing the various grade levels of the Detroit system. Dr. E. Lawrence Palmer of Cornell University discussed the "Teaching of Conservation before and after Pearl Harbor," furnishing a wealth of practical suggestions in his own incomparable style. Mr. O. E. Fink of Columbus, Ohio, outlined the worth-while conservation education and research carried on by the Department of Conservation in Ohio. Mr. Howard Michaud of the North Side High School, Fort Wayne, Indiana, presented Indiana's Conservation program by means of well-chosen color slides. Michigan's program was also presented visually by the colored photography of Mr. Walter Hastings of the Department of Conservation, Lansing, Mich.

The banquet was a colorful and truly friendly affair. Music was furnished by members of a high school orchestra, and table decorations of fall flowers and fruit artistically arranged by a former biology pupil of the chairman, Miss Lockwood. After welcoming remarks and introductions by the president of the *National Association of Biology Teachers*, the guest speaker, Dr. Max Peet, Professor of Neurosurgery at the University of Michigan, was introduced. The title of his address was "The Role of the Sympathetic Nervous System in the Diseases of Man." It was dynamic, timely, and most interestingly presented, provoking many questions from the audience.

Detroit's first Regional Meeting thus came to a close with the wish expressed by many that it become an annual affair.

BY THE WAY

Don't Neglect Field Work in the fall and early winter. The ponds and roadside ditches will furnish dozens of species of crustacea, aquatic insects, insect larvae, algae and the like; the woods have insect galls, lichens, seed pods and so forth; last summer's bird nests are still in good condition; although not quite so obvious, there is as much of biological interest as in spring or summer.

Before You Forget, go out and pick up a handful of dry grass and leaves, put them in a pint or quart jar of water and set the infusion in a window where some direct sunshine will reach it; you will soon have a fine collection of microorganisms.

When the Trees Have Shed their leaves, it is time to start the study of *winter twigs*. With a little practice trees can be identified by their twigs almost as easily as any other way. Note especially the size, shape, color, surface and arrangement of the buds.

Vallisneria, or "eel grass," is one of the best winter aquarium plants. It is a good oxygenator, grows rapidly, presents a good general appearance and thrives under a wide variety of conditions.

An Aquarium does not have to be a large tank. A common fruit jar has ample size for snails, leeches, small crustacea, water insects, cultures of algae and many other kinds of plants and animals.

To Mount Butterfly Wing Scales in their original pattern, coat a slide with balsam, varnish or lacquer; press the wing down on the sticky surface and remove it at once; allow to dry and mount in balsam in the usual way.

The Preparation of High-School Science Teachers

OSCAR RIDDLE
Carnegie Institution, Cold Spring Harbor, New York

Scientists and educators have frequently noted that the preparation of teachers of science and mathematics for small high-schools of this country is generally inadequate. It is also well known that improvement is and has been disappointingly slow. *The Cooperative Committee on Science Teaching* has till now concentrated its effort on finding a practical way of obtaining definite improvement in the preparation of these science teachers. It has just published a "Preliminary Report on the Preparation of High-School Science Teachers,"[1] and if its suggestions are to have value they must become known to scientists and educators generally. Comment from these groups at this time should assist the Committee in formulating its definitive report. Our purpose here is to give an outline of this (preliminary) plan to the readers of THE AMERICAN BIOLOGY TEACHER.

Biologists have rather special reason for interest in any plan which looks toward better preparation for those who teach their science in our small high-schools. Their own *Committee on the Teaching of Biology*, appointed by the Union of American Biological Societies, published last March a 76-page Report[2] with data which demonstrate the inadequate training of a majority of those who are asked to teach biology in our small high schools. Although the larger high-schools and better trained teachers were represented in relatively too great number among the 3,183 teachers of the 48 States who supplied data for that Report only 53% of them stated that as undergraduates they prepared to teach biology. Many teachers in small high schools have no more, sometimes less, than 5 hours of college credit in biology. That Report noted (p. 60) that "perhaps only a movement in which all natural science teachers work together with educators and administrators can hope to preserve or secure adequate instruction in biology in our schools." For such "team-work" the Cooperative Committee on Science Teaching seems well adapted. Its members were appointed by the following national organization (two members each): *The Union of American Biological Societies*, *The American Chemical Society*, *The American Association of Physics Teachers*, *The Mathematical Association of America*, and *The National Association for Research in Science Teaching*. More important segments of the Cooperative Committee plan are reproduced below.

It may be remarked that though this plan is based essentially upon the needs of peace-time education, the changes recommended also apparently fit into war-time demands for accent upon science and mathematics in our secondary schools.

NATURE OF THE PROBLEM

"The problem of teacher preparation in the sciences is located primarily in the

[1] R. J. Havighurst and others. *School Science and Mathematics*, October, 1942.

[2] O. Riddle and others. The Science Press, March, 1942.

small high-school, since one-half of them employ five teachers or less and three-fourths of them have ten teachers or less. The smallest school must teach at least twelve to fifteen subjects. . . . The problems of teacher preparation in large cities are different from those discussed in this report. . . ."

"The teacher in the small high school is usually prepared too narrowly by his college for the variety of subjects that a teacher in a small school must teach. The state certification authorities permit this because they do not require even a reasonable minimum of specific preparation in each subject which the teacher teaches. From this it develops that the problem has two related aspects. Both the college and the state certification authority must move, and move together, to meet the problem.

"The certification or licensing board is almost helpless if it works alone on the problem. More and more the colleges have been adopting standards of concentration in a major department which make it difficult and often impossible for an undergraduate to secure a good preparation for teaching in as many as three science fields. As a reaction from the insufferable rigidity (from the point of view of the principle of the small high school) of a one-subject teacher, it is but natural to go to the other extreme, befitting a frontier society, of expecting each teacher to be ready and willing to teach anything. . . ."

"In order to improve this situation in science and mathematics[3] the colleges must provide opportunity for a "concentration" which shall lie not in one department but shall spread (not too thinly) over at least three subjects among the sciences and mathematics. When the colleges provide a reasonably broad preparation in the sciences for the beginning teacher in a small high school, the certification authorities will be in a position to raise the standards for teachers' licenses. . . ."

The College Preparation of High-School Science Teachers

"The Committee is convinced that progress will be made in the preparation of science teachers only if the colleges consider that this preparation is of a professional nature and treat it as such. There should be a section in the college catalogue describing the program for the preparation of science teachers. This program should be worked out cooperatively by the science departments and the department of education. . . . It is thought that a reasonably satisfactory program can be worked out within the 120 semester hours usually required for the B.A. degree. Most students could obtain five to fifteen semester hours of credit beyond the 120-semester-hour minimum.

"The Committee favors a program which gives the prospective teacher a fair preparation in at least three sciences. Any combination of three of the following five subjects is recommended: biological science (including both botany and zoology), chemistry, earth science, mathematics, physics. . . ."

"The Committee recommends that approximately one-half of the prospective teacher's four-year college program be devoted to courses in the sciences. Sixty semester hours, divided among three sciences, will allow for a 24-hour major in one subject and 18 hours in each of two others. The 24-hour minimum applies to biology where preparation in both botany and zoology (physiology) is necessary.

"This is the heart of the Committee's recommendation—that half of the college

[3] In this report the term "science" usually includes mathematics.

program be devoted to work in three science subjects. Such a program allows for a reasonable degree of specialization and insures enough breadth to prepare the student reasonably well for the teaching assignments he may expect during his first years of teaching. This program leaves ample room for the usual "general education" requirements of the college and for the required professional courses in education. For the student who plans carefully and is given advice early enough, it even leaves room for 18 or 20 semester hours of a subject such as history or foreign language or music which a student may wish to take as an extra subject to be added to his teaching reportoire.

"One objection which may be raised against a comprehensive teaching major in the sciences is that it does not carry a student far enough in a particular subject to enable him to do graduate work in that subject. This objection can be answered by a requirement of 21 to 24 hours in at least one subject, which is enough to permit a student to go ahead with graduate study in a good graduate school, especially since it is supported by strong programs in two related sciences. . . ."

The Certification of High-School Science Teachers

"On this subject the Committee has proceeded cautiously, following the lead of educationists and scientists who have already worked on this problem. . . . Recommendations have recently been made for certification in broad subject areas, such as science, social studies, foreign languages, and we may expect to see experiments in that direction. The Committee's proposal is an approach to the broad area plan. . . ."

"At present, where certification is practised with respect to specific high-school subjects, the requirement for a certificate is often as low as five semester hours of college work in a subject. . . . The sciences of physics, chemistry, and biology, since they are usually offered in but one class in a small school, come off very poorly in terms of certification requirements. For example, the North Central Association of Colleges and Secondary Schools, which sets relatively high standards in the twenty states of its territory, considers 'science' as a single subject field and requires the same number of hours' preparation, namely, fifteen, in science that it requires in English, history, or mathematics. Thus a teacher may be certified to teach 'science' with fifteen hours distributed among the various sciences and need have only five hours of any particular science which he teaches, such as chemistry, or biology, or physics. At the same time, a teacher of mathematics must have fifteen hours of mathematics in order to be certified. . . ."

"The Committee recommends a policy of certification or licensing of teachers for three subjects to correspond to the program which teacher-training institutions are asked to adopt. The Committee recommends that a total of at least 60 semester hours' credit be required in the science area, with at least 18 hours' credit in each subject for which the certificate is granted, except that 24 hours' credit should be the minimum for certification in biology, including courses in both botany and zoology. For certification to teach general science in the junior high school only, the Committee recommends as an alternative to certification in three subjects the requirement of a minimum of 15 hours in biological science, 15 hours in physical science (including both physics and chemistry), 6 hours in earth science, and 6 hours in astronomy.

The Huxleyan System of Biology Teaching

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Huxley has been called "the father of modern laboratory instruction."[1] This statement, however, seems rather broad when we remember that Thomas Thomson established a chemical laboratory for general instruction in Glasgow eight years before Huxley's birth[2] while Justus Liebig was engaged in perfecting a laboratory method for teaching chemistry in Giessen during the decade in which Huxley was born.[3] Without a doubt we owe the introduction of the laboratory method in education to Liebig before all others.[4] But we are just as greatly indebted to Huxley for the establishment in the schools of a system of biological teaching based upon the use of "type forms" and first-hand laboratory work by the students. Huxley was one of the first to provide the student with a comprehensive introduction to general biology by means of lectures, text, demonstration, and direct laboratory work. Indeed Professor Geddes feels able to assert that "here was the very first of laboratories, as also of lectures truly and broadly biological."[5] In the promotion of such teaching Huxley's services can hardly be overestimated.[6]

In writing to his friend, John Tyndall, concerning this practical course in biology, Huxley speaks of it as "the commencement of a new system of teaching which, if I mistake not, will grow into a big thing and bear great fruit."[7] Huxley did not mistake the significance of this "new system of teaching," for unless Professor Pearl misjudges: "It truly did 'grow into a big thing'! All biological teaching today is modeled upon that course, and has not departed from, or essentially improved upon, any of the pedagogic principles embodied in it."[8]

The "new system of teaching" which Huxley inaugurated in his new laboratories at South Kensington was carried out from this center by his many capable demonstrators and students. Professor Vines spread the system to Cambridge under Sir Michael Foster.[9] Professor Martin, after he had been recommended by Huxley to President Gilman of Johns Hopkins University, established one of the first biological laboratories in America, and introduced Huxley's system here. A few years later when Henry Fairfield Osborn was called to Princeton as assistant professor of comparative anatomy, he introduced "the Huxley method of extemporaneous lectures and

[1] Osborn, Henry Fairfield, *Impressions of Great Naturalists*, p. 77, New York, Charles Scribner's Sons, 1924.

[2] von Meyer, Ernst, *A History of Chemistry*, Tr. McGowan, George, p. 648, London, Macmillan and Co., 1906.

[3] *Ibid.*, pp. 274–276.

[4] Cf. Armstrong, H. E., "Huxley's Message in Education," *Nature*, vol. 115, p. 743, May 9, 1925.

[5] Geddes, Patrick, "Huxley as Teacher," *Nature*, vol. 115, p. 741, May 9, 1925.

[6] Cf. Professor Jeffery Parker's statement as reprinted in Huxley, Leonard, *Life and Letters of Thomas Henry Huxley*, vol. I, p. 406, New York, D. Appleton and Company, 1901.

[7] *Ibid.*, p. 408.

[8] Pearl, Raymond, "Human Biology in Schools and Colleges," *School and Society*, vol. 42, p. 111, July 27, 1935.

[9] Cf. Bower, F. D., "Teaching of Biological Science," *Nature*, vol. 115, p. 713, May 9, 1925.

laboratory verification" to his classes.[10] Ten years later when he was called to Columbia University to lay the foundations of the department of zoology, he introduced the same method to still larger classes.[11] In less than thirty years Osborn's students and grand-students spread the Huxleyan method over the United States. Among the students who assisted in this missionary work we may mention McClure, Strong, Matthews, McGregor, Gregory, Lull, Osborn, Bensley, Forster-Cooper, and Beebe. Thus, in 1925 Osborn could estimate that "more than six hundred students are now profiting annually by this Huxleyan method in anatomy, neurology, embryology, and palaeontology in American, Canadian, and British universities."[12] Today we should have to increase Osborn's estimate considerably.

Huxley's method of biological teaching influenced not only the universities, but also the lower schools, although not to the same extent. Most of Huxley's own students during the summer were science teachers. On their return to their respective schools, they tried to introduce as much of the new method as equipment would permit. But the method at this level gradually formalized and dissection became as mechanical as the old gerund-grinding has been. Moreover, this is not the first example of the tendency of educators to fossilize the methods of great teachers.

[10] Osborn, Henry Fairfield, "Enduring Recollections," *Nature*, vol. 115, p. 726, May 9, 1925.
[11] *Ibid.*, p. 726.
[12] *Ibid.*, p. 726.

A copy of the *Preliminary Report of the Committee on Science Teaching* will be sent free of charge to anyone who writes for it to the Chairman, Robert J. Havighurst, The University of Chicago.

THE INDIVIDUAL IN THE BIOLOGY CLASS

In the training of each teacher of biology there have come at some time the scientific principles underlying the fact that each individual is vastly different from every other individual. Nevertheless, there is still a tendency to teach a class as though it were one unit-character rather than twenty-five or thirty personalities, each with a different character pattern.

Many have scoffed at the educational "notion" of letting the pupil do as he pleases. Familiar is the story of Johnny who came sadly to the primary teacher one morning with the following query: "Teacher, today do we gotta do what we wanna do?" Such an attitude is from the mind of an infant just released from the arms and watchful care of his mother. He still has a fear of being left alone in the dark. In High School we are dealing with young men and women who have grown into freedom of thought and action at home and would welcome more of it at school.

Nowhere else in the curriculum is there so wide a variety of subject matter and opportunity for an activity program as in biology. The inexperienced teacher might be excused for procedures which day after day allow students only one line of endeavor. It is the path of least resistance to pass out twenty-four dissecting pans, as many frogs, and dissecting sets, and give general directions to the group as a whole. Perhaps that day something has happened in the life of one of the adolescents in this class that would make nothing seem more abhorrent than being forced to examine the internal anatomy of a very dead animal. Perhaps the day before he has heard an interesting radio program that has

aroused curiosity for further research. This is the day he should be allowed to read from a well-stocked room library and to examine related exhibit mounts and specimens. Perhaps over the week end he has visited a zoo or an aquarium or any of the numerous educational exhibits our cities offer to the public. That experience would be more vital to him if he could study some specimens in the laboratory, observe their habits, write reports on them, and perhaps sketch them. A frog thrown in from nowhere for no apparent reason except that it appears next in the text book would be just like a long freight train obliterating a glorious sunset.

Numerous arguments arise against the variety program. First, there is the chaos that is expected to exist when young people do what they want to do. Secondly, there is the indifferent student who seems to want to do nothing. True, the problems that arise are myriad. So there must be within the teacher an active mind always planning new devices to meet new crises. Equipment in the laboratory is expensive and order must be maintained, so systematic storing and careful choice of laboratory assistants is imperative. A posted inventory of laboratory equipment is another aid when students are working at various activities.

It is most essential that the teacher take inventory of each class at the beginning of a new term. The more experienced teacher can handle this successfully in a few open discussions. Some, however, would prefer the questionnaire method of discovering why each student is taking biology. If there is reason to doubt the sincerity of some of the answers most schools have folders for each student which reveal much to the teacher in attempting to mold personality and adapt his course to various personality types. The activity of the teacher along these lines the first two weeks of the semester cannot be too greatly stressed. During this orientation period there might be an excuse for some interesting projects done by all members of the class—for example, taking a personal inventory of things in the laboratory to see who can make the longest list of all specimens he knows from previous experiences.

Teachers often complain of indolence and lack of interest among students. The teacher of biology has had opportunity to receive unlimited inspiration from his study in the world of living things and should teach to pass that inspiration to his students. To inspire youth there must be infinite resources of varied experiences beyond the required University courses. The youth of today are taking trips, seeing and hearing radio broadcasts to the extent that it behooves every teacher to go a step beyond, ever broadening his vision and exploring new fields. The average high school student cannot stay at one activity as long as the more mature student in the comparative anatomy class at college. With his dominant and radiant personality it is hard to remember how close to the cradle and far from the grave is the high school student. By the use of special rooms where the exceptional student may work with standardized tests and advanced laboratory manuals scholarship examinations and preparation for special professions can still be met without subjecting all of the students to work which has no appeal to them.

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A Suggested List of Principles for Biology at the Tenth Grade Level

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Many leading students of science methods have advocated for several years the importance of teaching an understanding of principles of science in our courses. With this thought in mind and in order to arrive at some of the more important principles that should be included in high school biology, the author has attempted to secure such a list.

The principles submitted to the judges were selected from most recent high school biology textbooks, books on science methods and from science education magazines. In the author's opinion the list was rather complete.

The original list was submitted to several outstanding high school teachers of biology and specialists in science at the college levels. Each judge was requested to score this set of principles along suggested lines which are included in this article. Comments of the judges were then weighed against the principles submitted, and the present list, included herein, was arrived at.

The instructions to the judges were as follows:

1. Do you think all are principles? If not, which, and why?

2. Are these principles well stated? If not, how would you state to improve?

3. Do you think additional principles should be added? If so, will you add some under the proper units?

4. Do you think any of the included principles should be eliminated? If so, which, and why?

5. Please use the back side of the sheet for your comments.

6. For your convenience Robertson's Criteria are included below:

Robertson's Criteria of a Principle. (*Third Digest of Investigations in the Teaching of Science*, by Frances D. Curtis, p. 4 and 5. 1939. Blakiston's Son and Co., Inc. Philadelphia, Pa.)

1. To be a principle, a statement must be a comprehensive generalization.
2. It must be true without exception within the limitations specifically stated.
3. It must be a clear statement of a process or an interaction.
4. It must be capable of illustration so as to gain conviction.
5. It must not be a part of a larger principle.
6. It must not be a definition.
7. It must not deal with some specific substance or variety, or with a limited group of substances.

BASIC LIST OF BIOLOGICAL PRINCIPLES ESSENTIAL TO AN ELEMENTARY COURSE IN BIOLOGY LISTED AS TO UNITS

I. Structures and Processes or Morphology and Physiology

1. The cell is the unit of structure and function in all organisms.

2. Protoplasm is the physical basis of all life.

3. The fundamental life processes in all living things show a marked degree of similarity.

4. All living things depend directly or indirectly on photosynthesis for food.

5. The sun is the source of nearly all the energy on the earth.

6. Energy cannot be created or destroyed, but can be transferred or transformed.

7. Energy changes accompany all chemical changes.

8. In general, the more highly specialized an organism is, the more likely it is to perish as the environment changes.

9. In order to carry on their life processes, all living things must have adequate supplies of energy in the form of food.

II. Ecology: Interdependence, Distribution, Adaption

1. Certain conditions are essential to all life.

2. Organisms must be adapted to their environments.

3. Interrelations between organisms tend to establish a finely adjusted balance in Nature.

4. Plants and animals are interdependent.

5. There is a constant struggle for existence among all living things.

6. Living things are not distributed uniformly or at random over the surface of the earth, but are found in definite zones and local societies where conditions are favorable to their survival.

7. All life is dependent on and is controlled by certain environmental conditions which include food, a certain range of temperature, and water.

8. The surface of the earth is undergoing constant changes; therefore, in order to survive, organisms must migrate, hibernate, or otherwise become adapted to these changes.

III. Behavior

1. All protoplasm has the property or irritability; that is, sensitivity to stimuli.

2. Reactions to stimuli constitute the behavior of all organisms.

3. Increasing complexity of structure is accompanied by increasing division of labor.

IV. Classification or Taxonomy

1. Increasing complexity of structure is accompanied by an increasing division of labor.

2. In general, living things give evidence of a definite progression from simple to complex forms.

3. All living things have a common origin.

V. Heredity or Genetics

1. All life comes from life.

2. The greater the similarity in structure between organisms, the closer is their kinship; the less the similarity in structure, the more remote is their common ancestry.

3. Living things tend to resemble their parents in major respects and to differ from them in minor respects.

4. Unit characters are usually inherited as such in accordance with definite laws. (Mendelian Laws.)

5. Acquired characters are not inherited.

6. The fundamental function of the germ-plasm is the perpetuation of the species, the body or soma-plasm serves as the vehicle for the germ-plasm.

7. Both heredity and environment are controlling factors in development.

VI. Conservation: Human Resources and Natural Resources

1. Many diseases are caused by specific micro-organisms.

2. Certain unchangeable natural laws govern and control most activities of living things.

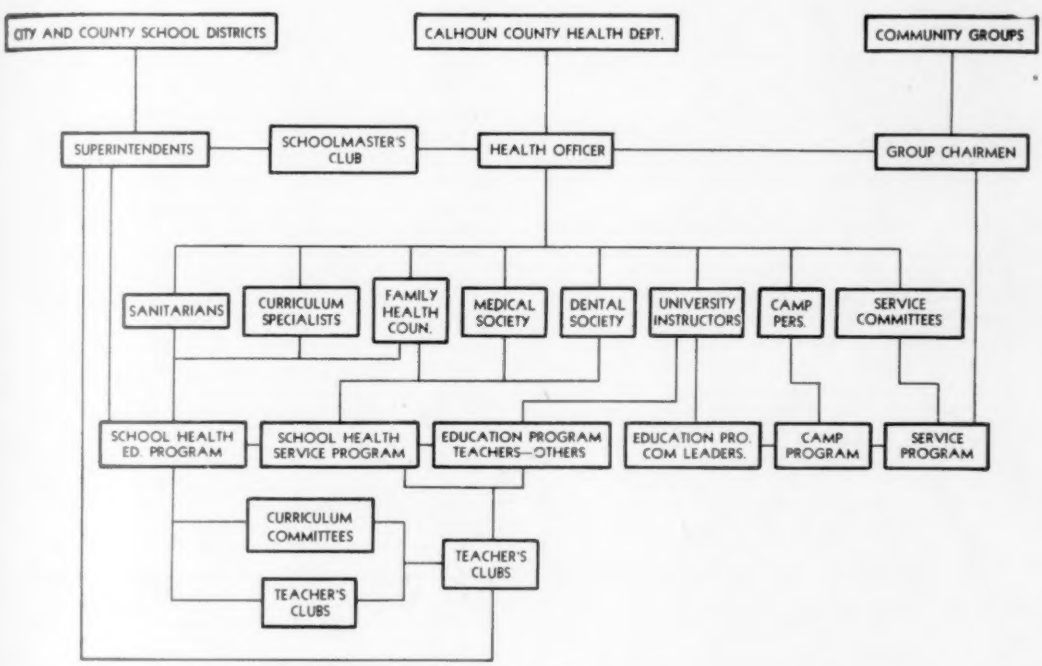
3. Those organisms which are best adapted to their environment are most likely to survive and to attain their fullest development.

4. Life succeeds only as it conforms with unchangeable natural laws which govern and control all activities.

AN EXAMPLE OF COMMUNITY ORGANIZATION

The accompanying diagram of the health education and service organization of Calhoun County, Michigan, was received too late to be included in the Health and Hygiene Issue (November) of THE AMERICAN BIOLOGY TEACHER. It should have appeared along with Dr. C. E. Turner's article *Community Organization for Health Education,* since it represents a specific example of the many-sided relationships among the various agencies there discussed. In order to grasp the complexity of the organization necessary for a modern community health program and the teacher's place in such a program the reader should study the diagram and the article together.

DIAGRAM OF ORGANIZATION—CALHOUN COUNTY, MICHIGAN



COMMITTEE REPORT AVAILABLE

Dr. Oscar Riddle's Committee on the Teaching of Biological Science, of the Union of American Biological Societies, has prepared a 76 page printed report on its analysis of a questionnaire on "The Teaching of Biological Science in the United States." Readers of *The American Biology Teacher,* libraries, and school officials may obtain a copy free upon request addressed to

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Books

DAVIS, WATSON (editor). *Youth Looks at Science and War.* A collection of essays by the Washington trip winners of the first annual talent search conducted by Science Clubs of America. Published jointly by Penguin Books, Inc., New York, and Science Service, Washington, D. C. viii + 136 pp. 1942. Twenty-five cents.

Those of us, among the teachers of science, who spend our days in association with the

secondary-school generation of future citizens will find relief from many misgivings in this brief book. The writers' optimistic trust in a future that seems so full of foreboding to some of us who are older; their willingness, even eagerness, to contribute their undoubted talents to the war effort and whatever lies beyond; their matter-of-factness in accepting difficult conditions as they are, with no trace of criticism of their elders who, perhaps, might have presented them with a far better world, if wisdom were not so frequently overcome by more selfish considerations; all these and more are here offered by some of the ablest youth of our land.

From bobby pins to sugar beets, from blood plasma to winning the peace, they show that they are not only on the front line, but frequently in the seclusion of their own private home laboratories have stepped over with their research into the realm where the possibilities are so numerous. And they do this so objectively and maturely it will gladden the heart of anyone who has struggled with the indifference and lack of understanding so characteristic of many of their contemporaries.

By all means, try to find the time to read this small volume. It will require hardly an hour. And at the end there is a copy of the test each one was required to take. This, with the self-scoring sheet included, may prove to be disconcerting, but it will increase your respect for our future scientists and your hope for all that lies ahead.

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GRIFFITH, JOHN Q., JR., M.D., and FARRIS, EDMOND J., PH.D. (editors). *The Rat in Laboratory Investigation.* J. B. Lippincott Co., Philadelphia. xviii + 488 pp. illus. 1942. $7.50.

This book is a veritable library of information on laboratory techniques involving the rat. It will interest technicians, breeders, research workers, teachers and anyone else who thinks in terms of experiments on the higher animals. Although described with specific references to the rat, many of the methods and principles would apply also to the mouse, guinea pig, rabbit and other similar animals. Teachers will probably find most interest in the chapters on general methods, anatomy, dietary requirements and behavior. There is a total of twenty-two chapters, written by thirty nationally known authorities, covering the above-named topics and also breeding, embryology, physiology, radiology, surgery, parasitology, diseases, histological methods and still others. The authors of course vary in technicality of language and style, but there is more continuity of thought than is usual in books written by so many collaborators. Many of the 178 excellent illustrations are in color. About 30 tables, including a 36-page one on dosages of chemicals, add greatly to the reference value of the book. The chapters are followed by extensive bibliographies. The index is comprehensive and well arranged.

JOHN BREUKELMAN

WEATHERWAX, PAUL. *Plant Biology.* W. B. Saunders Company, Philadelphia. 455 pp. 417 illustrations on 182 figures. 1942. $3.25.

The book is written for an elementary course in Botany. It is clear, concise, and avoids an excessive use of technical terms. The illustrations are well used to emphasize points in the text. The first two-thirds of the book is given to the general principles of botany, using well-selected plants to clarify the ideas. The parts of the plant and their structure are directly associated with the physiology of the whole plant. Separate chapters on growth, responses, and reproduction cover those subjects. An unusually fine, simplified chapter on heredity completes the first part of the book.

The last one-third of the book starts with a chapter on taxonomy and leads to a discussion of each of the different classes of plants. The evolution of plants is stressed, which leads to the chapter on the dispersal of seeds. The final chapter is on plant ecology, a recent addition to the study of elementary botany. Each chapter has a summary, and at the end of the book is a glossary of some 400 terms.

HOMER A. STEPHENS

One of the Curtiss-Wright Airplane Division classrooms for training U. S. Army ground crews.